FOREWORD

Pedestrian research may be on its way to coming of age. A session devoted exclusively to the subject was presented for the first time at the 51st Annual Meeting of the Highway Research Board.

In this RECORD we have papers on the pedestrian and crosswalk effectiveness, walking trip length, accident causes and possible cures, rights to urban space, and vehicle-free zones.

Marked crosswalks have been assumed to prevent accidents to their users. Herms, using data covering a 5-year period for the simple situation of accidents at marked and unmarked crosswalks, found the unmarked superior. He believes that this may be due to the pedestrian's attitude and lack of caution when using the marked crosswalks.

How far do people walk? Maring satisfied his curiosity on the subject by conducting a survey of walkers in a largely high socioeconomic level apartment dwelling section of Washington, D. C. A tendency was found for people to take walking trips of about one-third of a mile.

It is a truism that anything that can cause an accident will. In practice, however, we need to concentrate on those factors that most frequently cause accidents. Snyder, after studying many pedestrian accidents, found that half of them could be classified into five frequent types. Based on a logical analysis, he has suggested possible solutions.

Fruin has highlighted the tendency for machine transportation to isolate the pedestrian on an "ever-narrowing sidewalk enclave." He believes there is a need to give the pedestrian a greater right to urban space.

The merits of physical separation of motor vehicles and pedestrians are discussed by Orski. Besides safety there can be benefits from the standpoint of a purer environment.

All in all, these papers take up the cause of the "second-class citizen"—the pedestrian—and rather objectively provide data and/or schemes for giving him a better deal in the walker-motor vehicle system.

—Robert B. Sleight

PEDESTRIAN CROSSWALK STUDY: ACCIDENTS IN PAINTED AND UNPAINTED CROSSWALKS

Bruce F. Herms, Traffic Engineering Section, City of San Diego

This is a report of a study of pedestrian accident experience at unsignalized intersections and whether it is less in marked or unmarked crosswalks. Accident experience covering a 5-year period was studied at 400 intersections, each having one marked and one unmarked crosswalk crossing the main thoroughfare. In addition, pedestrian and vehicle traffic characteristics were studied to determine the pedestrian's relative use of marked and unmarked crosswalks and his exposure to vehicular traffic. The results show that during the 5-year period 177 pedestrians were hit in the 400 marked crosswalks compared with 31 pedestrians hit in the 400 corresponding unmarked crosswalks. This included 18 fatalities in the marked crosswalks versus 3 fatalities in the unmarked crosswalks. In general, the study showed that, in terms of the number of pedestrians using the crosswalks, approximately twice as many pedestrian accidents occur in marked crosswalks as in unmarked crosswalks. Evidence indicates that the poor accident record of marked crosswalks is not due to the crosswalk being marked as much as it is a reflection on the pedestrian's attitude and lack of caution when using the marked crosswalk. Recommendations include a pedestrian education program and limiting crosswalks to only those locations where warranted.

•PAINTED or marked pedestrian crosswalks (the terms "painted" and "marked" are used interchangeably in this report when referring to crosswalks) are one of the most commonly used pedestrian traffic control devices. Yet, little research has been conducted to evaluate their effectiveness as a "safety" device. An obvious approach toward checking this effectiveness would be to compare the accident experience of a marked crosswalk with that of an unmarked crosswalk.

One of the difficulties encountered when conducting a comparison study is the problem of maintaining equivalent conditions. If one intersection is compared with another, it is likely that a multitude of unrelated variables will enter the picture: differences in volume, turning movements, orientation, and environment, to name a few. If the same intersection is compared with itself on a before-and-after basis, it is possible that other undetectable variables may occur with respect to time: shifting traffic patterns, unrelated weather conditions, and seasonal differences.

PHASE I

Phase I of this study attempted to keep the variables to a minimum by adopting the following criteria:

1. Use of a single time period;
2. Use of only those intersections that have one painted crosswalk and one unpainted crosswalk, both crossing the same main thoroughfare (Figs. 1-4)—this means that, for all practical purposes, the vehicular traffic crossing each painted crosswalk would be nearly the same as the traffic crossing the corresponding unpainted crosswalk;
3. Use of only those crosswalks crossing the major flow of traffic—crosswalks on minor legs were not considered;
4. Use of only unsignalized intersections;

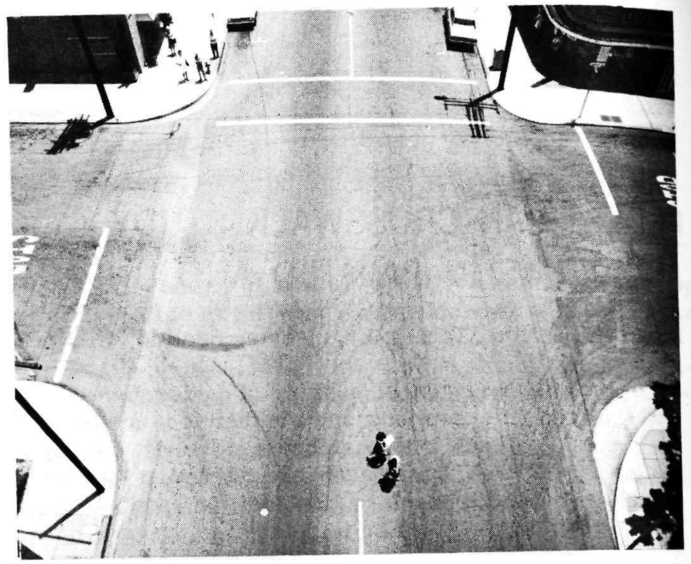


Figure 1. Aerial view of First Avenue at Juniper Street, a typical 4-leg perpendicular intersection having one marked and one unmarked crosswalk across the main thoroughfare. Minor streets are controlled by stop signs and stop bars. ADT on the main street is approximately 5,800 vehicles per day; total pedestrian volume crossing the main street is about 1,100 persons per day.

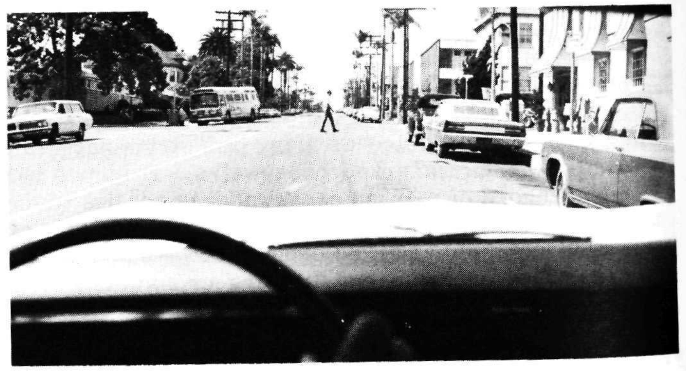


Figure 2. Motorist's view of marked crosswalk at First Avenue and Juniper Street from about 100 ft away.

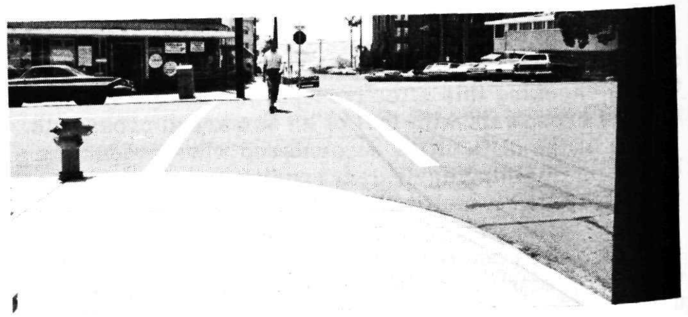


Figure 3. Pedestrian's view of marked crosswalk at First Avenue and Juniper Street; approximately 780 pedestrians use this crosswalk each day. Crosswalk is delineated by means of plastic material.

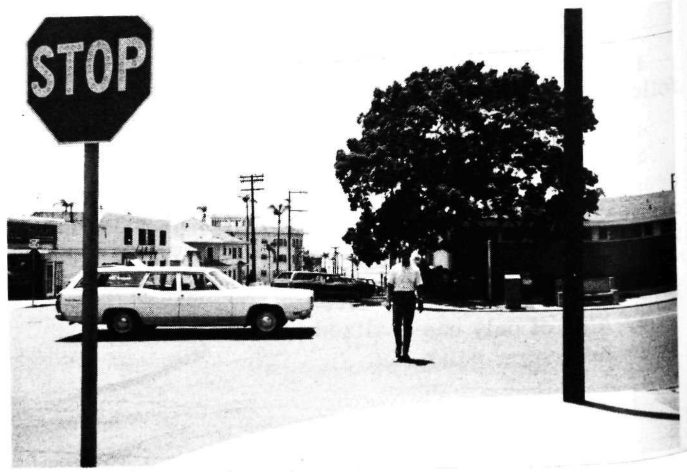


Figure 4. Pedestrian's view of unmarked crosswalk at First Avenue and Juniper Street; approximately 320 pedestrians use this crosswalk each day.

5. Exclusion of school crosswalks because the nighttime visibility characteristics of the yellow paint might affect the study results;

6. Exclusion of midblock crosswalks; and

7. Exclusion of any intersection having unusual flow patterns, sight distance problems, or unusual geometrics that could affect the results (Tee intersections and offset intersections were included).

To further minimize the effect of chance variables, it was decided to obtain as large a sample as possible and extend the observations over as long a period as practical. Therefore, a 5-year observation period was established, and a total of 400 intersections were found that met the necessary criteria (Fig. 5).

In tallying the pedestrian accidents during the study period, several other guidelines were adopted to ensure consistency.

1. In the painted crosswalk, only those pedestrian accidents occurring within the confines of the crosswalk were counted.

2. In the unpainted crosswalk, where it might be difficult for the reporting officer to determine the crosswalk limits, it was decided to count all pedestrian accidents within an arbitrary 20-ft zone to make certain that no borderline pedestrian accident was overlooked. (This in effect amounted to overcounting the pedestrian accidents at the unpainted crosswalk.)

3. No bicycle accidents were counted as pedestrian accidents.

4. Only valid pedestrian accidents were counted. If, for example, a person were struck while directing traffic, it would not be counted as a typical pedestrian accident.

5. In those accidents involving more than one pedestrian, the age of the eldest pedestrian was used for age tally purposes.

PHASE II

It is recognized that an accident study of painted and unpainted crosswalks at the same intersection would be of questionable value unless it could be related to the amount of pedestrian use. In other words, if no pedestrians use a certain route, one would hardly expect any pedestrian accidents to occur there.

To clarify this matter, it obviously would be desirable to have pedestrian counts at each crosswalk to correspond with the accident history. Comprehensive pedestrian volume counts are difficult and expensive to obtain. In the initial study (Phase I), a compromise procedure was adopted whereby 4-hour manual counts were obtained at 40 of the 400 intersections. These counts covered the period from 2 to 6 p.m. (7).

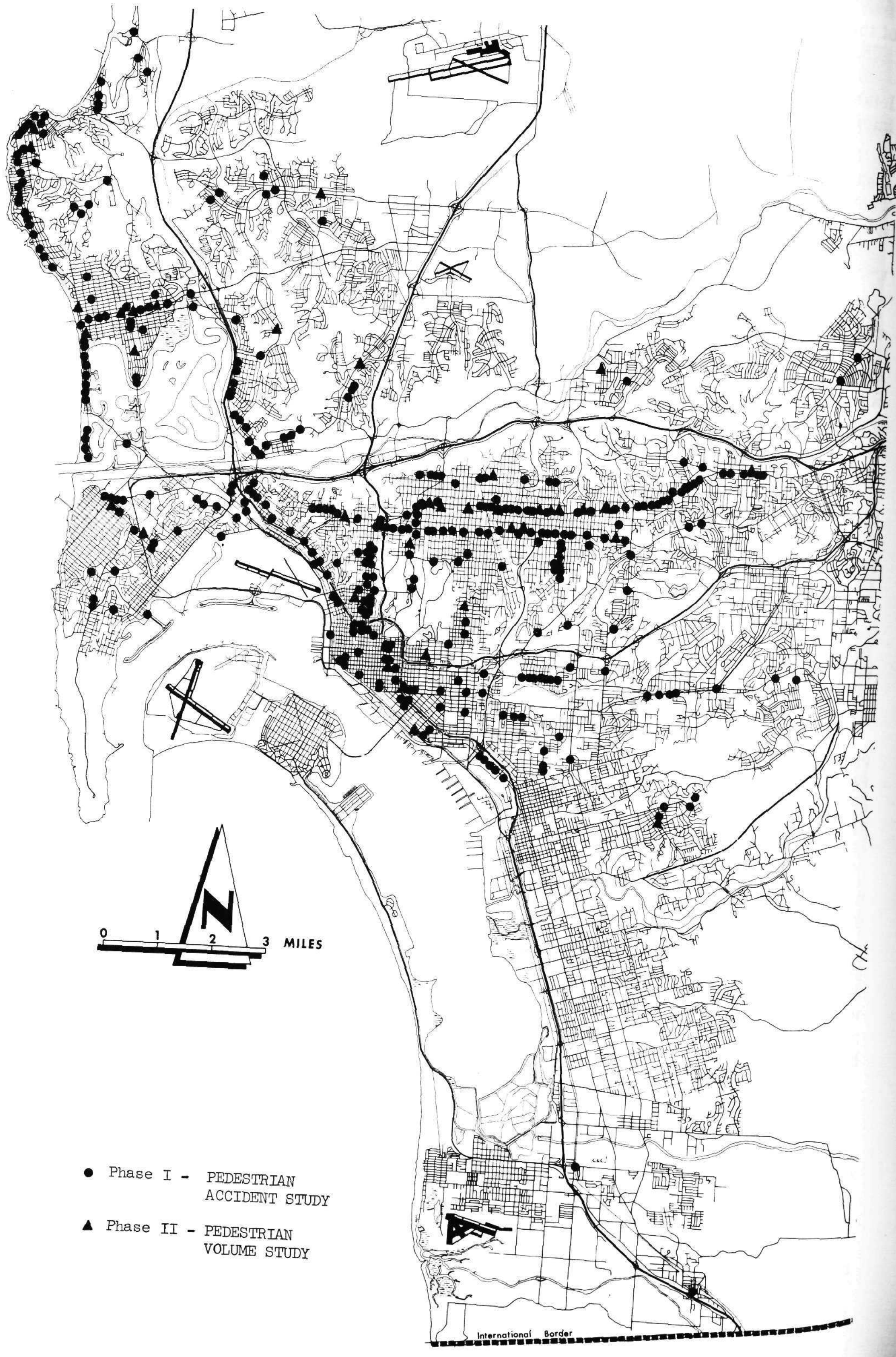
Because these counts covered such a short period of the day, it was felt that the data were not necessarily indicative of the overall daily pedestrian traffic. Fortunately, under provisions of the Federal Highway Safety Act of 1966 and with the assistance of the California State Office of Traffic Safety, the City received a grant to make it possible to gather additional pedestrian volume data based on 24-hour counts (Phase II).

Several possibilities for conducting this study were explored, including the possible use of time-lapse 16-mm cameras. But in view of the amount of data to be tabulated and analyzed, it was decided that conventional manual counting techniques performed by part-time student engineers would be the most efficient and economical method.

Excluding periods when schools are not in regular session, there are approximately 175 weekdays per year that qualify for making counts, assuming satisfactory weather and counting conditions. In terms of available time and personnel, it would take over 2 years to count all 400 intersections. Therefore, it was decided to provide a 10 percent sample by counting 40 intersections, each for 24 hours. This involved about 2 months of counting time. These counts were made during the fall of 1969 (Oct. 10 through Dec. 18, excluding weekends and holidays).

Briefly, the counts were obtained by using a team of men counting from midnight to midnight in eight 3-hour shifts. Supplementary help was provided whenever it appeared advisable. The count personnel were screened and indoctrinated in the office. Training was accomplished in the field by having the new count personnel make duplicate field

Figure 5. Location map of crosswalks under study.


N
0 1 2 3 MILES
● Phase I - PEDESTRIAN ACCIDENT STUDY
▲ Phase II - PEDESTRIAN VOLUME STUDY
International Border

counts along with experienced crewmen until they learned the procedure and could maintain consistently accurate counts. Close liaison was maintained with the field crew at all times during the counting operations to ensure continuity and quality of data.

In order to obtain compatible data, manual counts were limited to nonholiday weekdays. In the event of inclement weather, accidents, construction, or other conflicting conditions, supplementary counts were made to ensure representative data. To ensure further compatibility of data, counts were made only at 4-leg perpendicular intersections at which the main thoroughfare carries two-way traffic.

Standard intersection manual counting procedures were employed using an intersection tally board that counted (a) the vehicular traffic entering the intersection on each leg by individual traffic movements—right turns, straight-through, and left turns—and (b) the nondirectional pedestrian traffic crossing each leg of the intersection (Fig. 6).

In view of the mass of field data to be tabulated and analyzed during and after the field study, it was decided to utilize the City of San Diego's IBM 360 computer. To facilitate this, the field sheets were designed as source documents (Fig. 7). This permitted direct keypunching and subsequent computation and summarization by electronic data processing.

A special computer program was prepared that summarized and printed the count data, exposure ratios, and crosswalk use ratios for rach intersection and then combined each data element to provide a composite intersection count representing all of the intersections counted (Table 3).

To aid in the evaluation of the volume data at the 40 intersections, a supplementary 5-year accident analysis was made for the 40 intersections only. In past years, the City of San Diego maintained only 3 years plus the current year of accumulated traffic accident records in its files. This policy was changed in 1968 to permit the accumulation of 5 years of accident records. Unfortunately, the 1963 accident records were no longer available for the purpose of making a 40-intersection composite collision diagram analysis (Fig. 12). Consequently, the latest 5-year period was used, covering January 1, 1965, through December 31, 1969.

FINDINGS

Table 1 gives the number of pedestrian accidents occurring in marked and unmarked crosswalks by month and year. The total number of fatal pedestrian accidents occurring in the 400 intersections during the 5-year period was 18 in the marked crosswalks and 3 in the unmarked crosswalks. This represents an accident ratio of 6:1. During this same period, the total pedestrian accidents (fatal and nonfatal) occurring was 177 in marked and 31 in unmarked crosswalks, representing a ratio of 5.7:1.0. The month showing the highest 5-year accumulation of accidents is December, with 24 accidents occurring in marked crosswalks and 7 accidents in unmarked crosswalks. July was the month during which the least number (7) of pedestrian accidents occurred in marked crosswalks. September showed a surprising record of no pedestrian accidents occurring in the unmarked crosswalks for the 5-year period.

In Table 2 the number of pedestrian accidents in marked and unmarked crosswalks is arranged by day of week and time of day. In the marked crosswalks the highest incidence of accidents occurred on Saturday, with 38 accidents; the lowest incidence was on Tuesday, with 13. In the unmarked crosswalks, the highest incidence of accidents was on both Tuesday and Friday with 7 accidents each; the lowest incidence was on Wednesday, with 1 accident.

Figure 8 shows pedestrian accidents in marked and unmarked crosswalks compared by pedestrian age groups. As might be expected, the highest incidence of pedestrian accidents involves the very young and the very old in both the marked and unmarked crosswalks. For example, the highest incidence of accidents for both the marked and unmarked crosswalks involved those persons 70 years or older, with 35 accidents in marked and 7 accidents in unmarked crosswalks. This was followed closely by the 5- to 9-year age group, with 29 accidents in marked and 6 accidents in unmarked crosswalks. There were, however, some surprising paradoxes found in the remaining age group data. For example, the 65- to 69-year age group was involved in 13 accidents

Figure 6. Student engineer making manual count at intersection. Pocket watch is used for timing the count; supplementary timer on dashboard is used to warn personnel in advance of the count-recording interval each half hour.

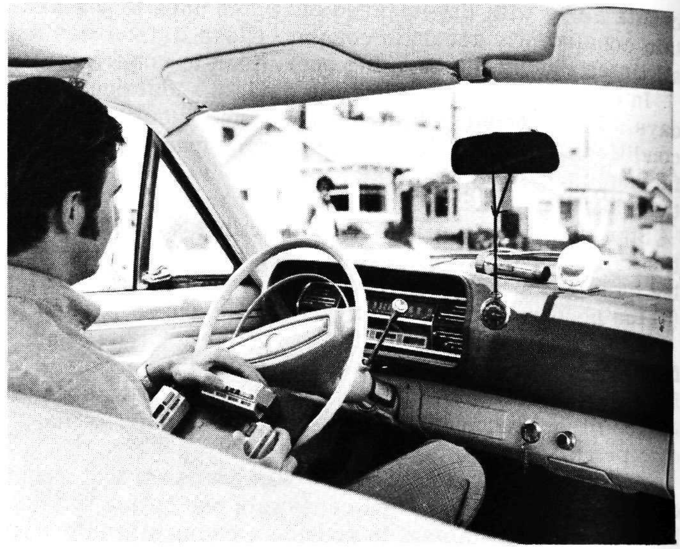


Figure 7. Student engineer recording count data on special field form adapted for subsequent keypunching and electronic data processing.

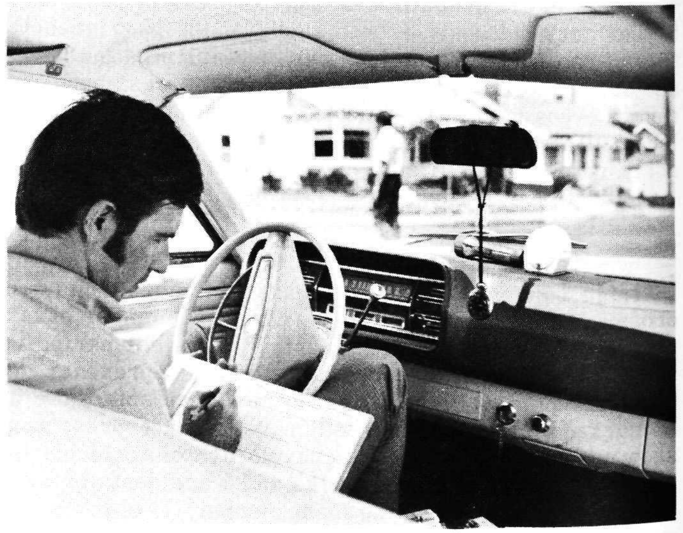


Table 1. Pedestrian accidents in marked and unmarked crosswalks by month and year.

	Fatal Accidents		Fatal and Injury Accidents by Year											
			1963		1964		1965		1966		1967		Total	
Month	M	U	M	U	M	U	M	U	M	U	M	U	M	U
January	2		5	2	4	1	4	0	4	0	1	0	18	3
February	1		1	0	6	1	4	0	2	0	3	0	16	1
March	2		4	0	2	0	5	1	3	0	3	0	17	1
April			1	0	2	0	4	1	3	0	2	1	12	2
May		1	3	0	2	0	2	1	4	1	4	1	15	3
June	1	1	1	1	4	0	3	0	2	2	1	0	11	3
July	1		0	2	2	1	2	0	2	0	1	0	7	3
August	1		3	0	0	0	2	1	3	0	3	1	11	2
September	3		3	0	1	0	1	0	4	0	2	0	11	0
October	1	1	6	1	1	0	4	1	3	0	3	0	17	2
November	3		2	0	5	1	5	0	2	1	4	2	18	4
December	3		3	1	6	4	6	0	2	1	7	1	24	7
Total marked	18		32		35		42		34		34		177	
Total unmarked		3		7		8		5		5		6		31

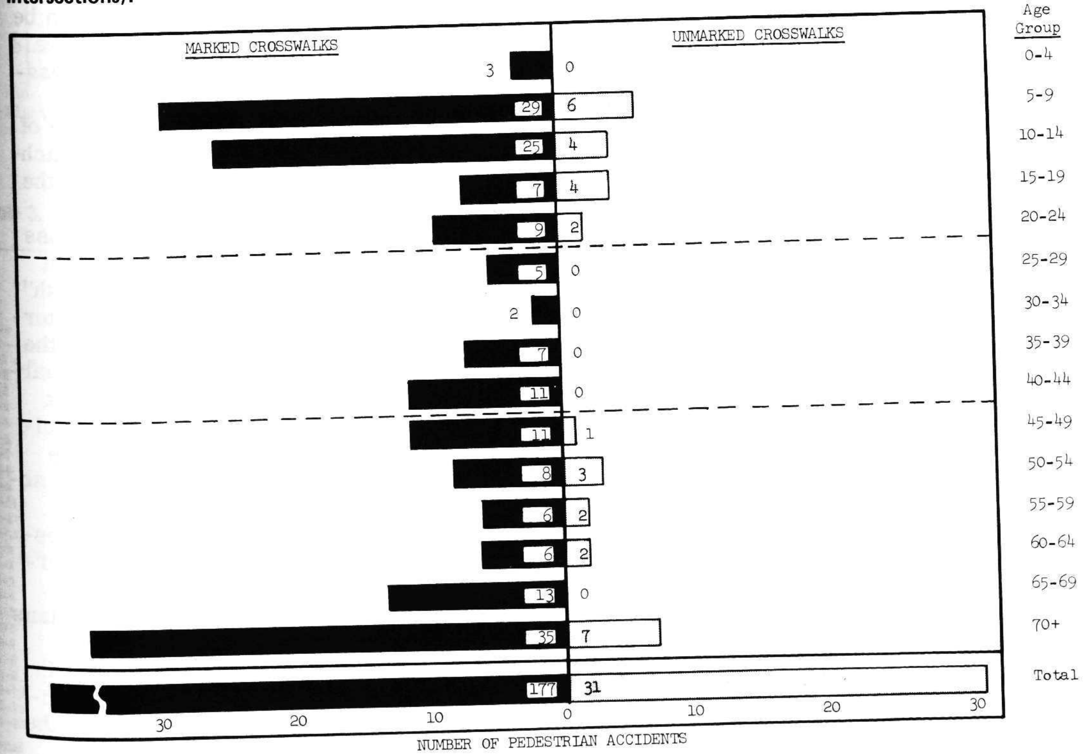
Based on 5 years of data at 400 intersections.
M = marked crosswalks, U = unmarked crosswalks.

Table 2. Pedestrian accidents in marked and unmarked crosswalks by time and day of week.

	Day														Total	
	Mon.		Tue.		Wed.		Thur.		Fri.		Sat.		Sun.			
Time	M	U	M	U	M	U	M	U	M	U	M	U	M	U	M	U
12-1 a.m.							2				1			1	3	1
1-2											2				2	0
2-3									1				1		2	0
3-4														1	0	1
4-5															0	0
5-6															0	0
6-7					1										1	0
7-8	1	2	2		2		1	2		1	1				7	5
8-9			1	1			1		1						3	1
9-10	1		1		1							2			3	2
10-11		1			1				1			1			2	2
11-12							1		2		4				7	0
12-1 p.m.	2		1		1	1			1	1	1		1		7	2
1-2	1				2					1	3		1		7	1
2-3	2									1	2		1		5	1
3-4	3		3	1	3		1		1		2				13	1
4-5			1	2	3		1		3		3		1		12	2
5-6	1		5		11		2		4		2		1		26	0
6-7	1		6		2		1		5		5		3		23	0
7-8	3		1	2					4		3	1	4		15	3
8-9	1		1		4		2	1	3		4	1	3		18	2
9-10	1		1	1	2		1	1		2	1	1	2		8	5
10-11					2			1	1		2		1		6	1
11-12			2						2	1	2		1		7	1
Total marked	17		25		35		13		29		38		20		177	
Total unmarked		3		7		1		5		7		6		2		31

Based on 5 years of data at 400 intersections.
M = marked crosswalks, U = unmarked crosswalks.

Figure 8. Pedestrian accidents in marked and unmarked crosswalks by age group (based on 5 years of data at 400 intersections).



in marked crosswalks but showed no involvement during the same period in unmarked crosswalks. Similarly, the 25- to 44-year age group showed an involvement of 25 accidents in marked crosswalks, but during this same period they showed no accident involvement in unmarked crosswalks.

Figure 9 is a graph of pedestrian accidents occurring in marked and unmarked crosswalks plotted as a function of the time of day. The time intervals showing the highest incidence of accidents during the 5-year period are 5 to 6 p. m., with 26 accidents, and 6 to 7 p. m., with 23 accidents. These accidents occurred in marked crosswalks. Interestingly, the unmarked crosswalks showed no accidents during the same time intervals. This represents an accident ratio of 49:0. The unmarked crosswalks show peak accidents occurring at 6 to 7 a. m., with 5 accidents, and 8 to 9 p. m., also with 5 accidents. The accident ratio is 5.7:1.0 in marked versus unmarked crosswalks.

Table 3 is the manual count summary for the composite 40 intersections (Phase II). This is based on the 24-hour pedestrian and vehicle volume counts made at 40 of the 400 unsignalized intersections having marked and unmarked crosswalks. The exposure ratio indicates the ratio of vehicles to pedestrians crossing the major street at the marked (leg 1) and unmarked (leg 3) crosswalks. The crosswalk use ratio indicates the ratio of pedestrians using the marked crosswalk versus the number of pedestrians using the unmarked crosswalk. This is shown as 2.86 pedestrians using the marked crosswalk to 1.00 pedestrian using the unmarked crosswalk.

Figure 10 is a graph of pedestrian volumes in marked and unmarked crosswalks plotted as a function of the time of day. The volume ratio (crosswalk use ratio) is 2.9 persons crossing in the marked crosswalks to 1.0 person crossing in the unmarked crosswalks.

Figure 11 is an intersection traffic flow diagram showing the composite volumes for the 40 sample intersections.

Figure 12 is a collision diagram showing the pedestrian accidents in the marked and unmarked crosswalks at the composite 40 sample intersections. Pedestrian accidents are based on the most recent 5-year period (1965-1969). From this diagram it can be seen that 56 pedestrian accidents occurred in the marked crosswalk versus 12 in the unmarked crosswalk. This includes 7 fatal pedestrian accidents in the marked crosswalk versus 3 in the unmarked crosswalk.

A further analysis can be made that relates the accidents to the relative position of the pedestrian and vehicle. Of importance here is (a) whether the vehicle is approaching the crosswalk from the nearside or far side of the intersection and (b) whether the pedestrian is just starting to cross the street or just finishing crossing the street. Note that "finishing" in this analysis means that the pedestrian is over halfway across the street. Of special interest in this group of accidents is the fact that the greatest number of pedestrian accidents (24, including 5 fatal) occurred at the "far-side finish" position. In other words, the vehicle struck the pedestrian on the far side of the intersection while the pedestrian was finishing crossing the street. This is contrary to the popular expectation that the majority of pedestrian accidents tend to occur at the "nearside starting" position. In fact, the nearside starting position showed up somewhat favorably in this analysis, with only 6 pedestrian accidents, none fatal. These 6 accidents represent only 8.8 percent of the total 68 pedestrian accidents occurring in the 40 sample intersections. Also of interest is the fact that only 2 of the 68 pedestrian accidents (on the major street) involved vehicles making turning movements from the minor street. Both of the turning accidents involved left turns. There were no pedestrian accidents involving right-turning vehicles in this sample of 40 unsignalized intersections.

Of special concern is the high proportion of nighttime accidents involving pedestrians being hit after they were over halfway across the street. One explanation is that the approaching vehicle's head lamps are not illuminating the pedestrian sufficiently and in time to permit the motorist to stop. [Another study (10) shows that under certain conditions the pedestrian may be some distance from the point of impact at the moment the motorist must perceive the danger and come to a safe stop.] Pedestrians should be made aware of this potential danger so that they avoid walking into the path of an oncoming vehicle at night, thinking that the vehicle will stop in time.

Figure 9. Pedestrian accidents in marked and unmarked crosswalks as a function of time of day (based on 5 years of data at 400 intersections).

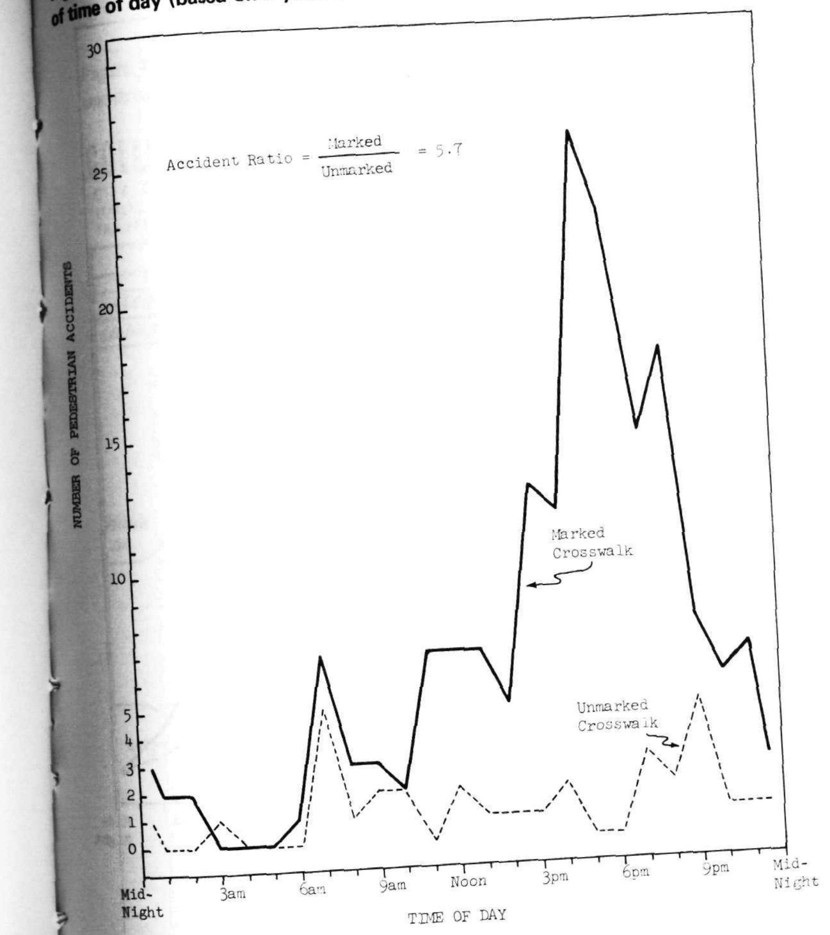


Table 3. Manual count summary, composite of 40 intersections.

Time	Marked Crosswalk								Unmarked Crosswalk							
	Leg 1				Leg 2				Leg 3				Leg 4			
	RT	ST	LT	PED	RT	ST	LT	PED	RT	ST	LT	PED	RT	ST	LT	PED
12-1 a.m.	104	3,224	106	14	98	81	71	27	104	3,309	115	10	83	35	66	61
1-2	64	1,840	60	11	55	36	23	17	71	1,877	83	8	58	41	49	50
2-3	48	1,278	32	8	23	29	26	13	29	1,199	49	4	30	15	25	30
3-4	12	756	22	4	19	15	23	4	25	734	26	0	25	6	19	6
4-5	23	700	18	9	38	22	20	5	12	632	30	3	17	12	26	9
5-6	90	2,022	44	33	87	54	68	28	55	1,983	76	12	65	28	83	26
6-7	300	8,580	251	123	329	251	254	129	226	8,405	214	41	292	308	309	122
7-8	639	21,645	535	500	836	545	454	573	508	19,677	539	161	756	527	418	452
8-9	686	17,483	582	688	697	524	455	686	542	16,911	536	253	689	376	360	526
9-10	509	15,808	549	489	623	427	457	649	571	14,964	520	165	603	290	371	487
10-11	585	18,001	544	619	686	453	505	926	688	17,638	656	237	656	317	423	789
11-12	717	20,489	715	796	773	580	582	974	754	19,580	777	239	776	383	487	914
12-1 p.m.	764	21,437	756	844	806	590	545	986	761	21,116	819	301	894	400	507	1,038
1-2	714	21,071	712	702	819	536	594	946	731	20,575	763	267	833	368	484	990
2-3	854	22,659	772	852	828	574	601	1,230	776	22,754	994	309	915	453	465	1,234
3-4	984	25,178	932	1,287	1,039	756	648	1,646	990	25,128	1,085	473	889	538	469	1,500
4-5	1,116	27,626	1,200	1,030	1,237	894	668	1,177	1,072	28,706	1,328	310	1,057	597	557	1,138
5-6	1,057	26,870	1,191	766	1,105	758	634	878	1,029	28,337	1,234	250	1,057	596	497	810
6-7	673	19,612	754	416	777	444	533	619	668	19,572	715	119	730	364	451	571
7-8	528	16,765	584	301	605	369	442	442	556	16,315	617	98	582	271	390	465
8-9	408	12,467	461	250	407	275	357	333	469	12,675	440	98	447	224	302	392
9-10	418	11,873	371	169	333	201	256	262	384	12,226	425	79	329	210	246	296
10-11	237	8,308	265	93	228	146	192	135	255	8,711	268	47	214	130	198	210
11-12	241	6,140	183	53	162	116	127	100	152	6,033	207	30	136	92	159	121
Total	11,771	331,833	11,639	10,057	12,610	8,676	8,535	12,785	11,428	329,057	12,516	3,514	12,133	6,581	7,361	12,237
Approaching			355,243				29,821				353,001				26,075	
Departing			349,028				29,648				352,501				32,963	
Total			704,271				59,459				705,502				59,038	
Exposure ratio (vehicles per pedestrian crossing major street): Leg 1 (marked crosswalk)											70.03					
Leg 3 (unmarked crosswalk)											200.77					
Crosswalk use ratio (pedestrians in marked versus unmarked crosswalks):											2.86					

RT = right turns, ST = straight, LT = left turns, PED = pedestrian.

Figure 10. Pedestrian volume in marked and unmarked crosswalks as a function of time of day (based on 24-hour manual counts at 40 intersections).

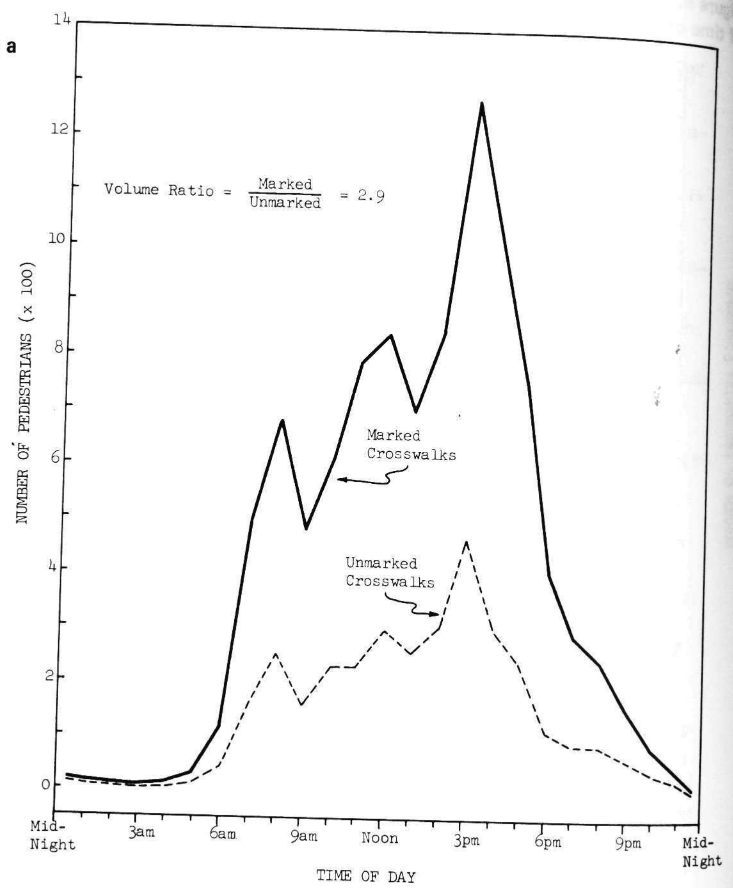


Figure 11. Intersection traffic flow diagram showing composite volumes of 40 intersections (based on 24-hour manual count data at 40 intersections).

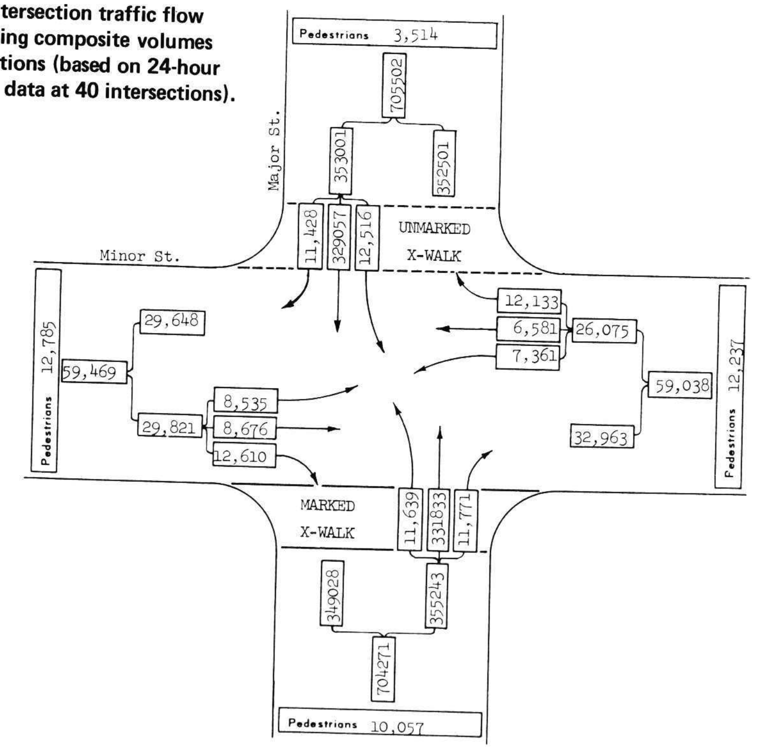
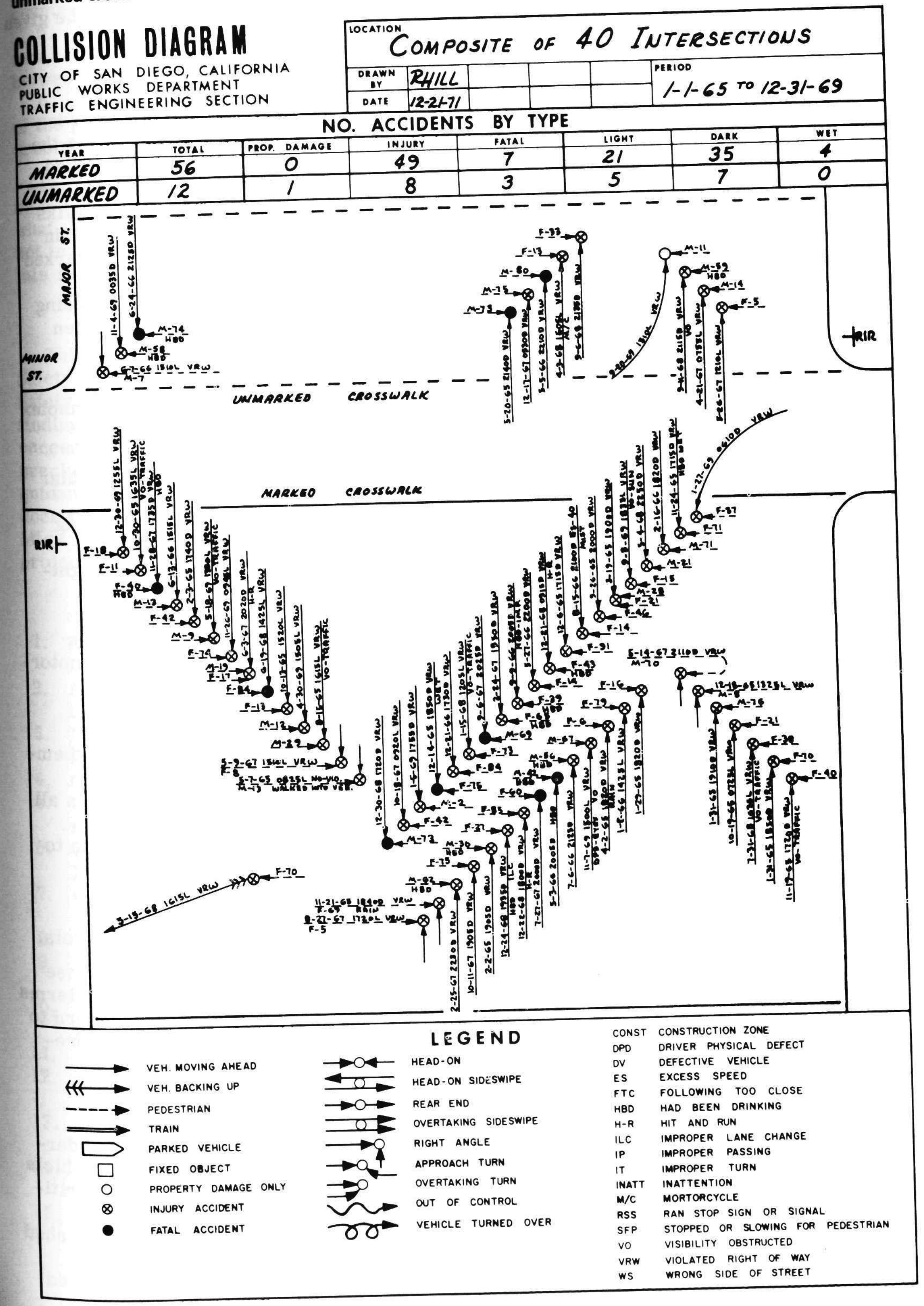


Figure 12. Intersection collision diagram showing composite collisions involving pedestrians in marked versus unmarked crosswalks at 40 intersections (based on 5 years of data).



COLLISION DIAGRAM
CITY OF SAN DIEGO, CALIFORNIA
PUBLIC WORKS DEPARTMENT
TRAFFIC ENGINEERING SECTION

LOCATION COMPOSITE OF 40 INTERSECTIONS
DRAWN BY RHILL
DATE 12-21-71
PERIOD 1-1-65 TO 12-31-69

NO. ACCIDENTS BY TYPE

YEAR	TOTAL	PROP. DAMAGE	INJURY	FATAL	LIGHT	DARK	WET
MARKED	56	0	49	7	21	35	4
UNMARKED	12	1	8	3	5	7	0

CONST	CONSTRUCTION ZONE
DPD	DRIVER PHYSICAL DEFECT
DV	DEFECTIVE VEHICLE
ES	EXCESS SPEED
FTC	FOLLOWING TOO CLOSE
HBD	HAD BEEN DRINKING
H-R	HIT AND RUN
ILC	IMPROPER LANE CHANGE
IP	IMPROPER PASSING
IT	IMPROPER TURN
INATT	INATTENTION
M/C	MORTORCYCLE
RSS	RAN STOP SIGN OR SIGNAL
SFP	STOPPED OR SLOWING FOR PEDESTRIAN
VO	VISIBILITY OBSTRUCTED
VRW	VIOLATED RIGHT OF WAY
WS	WRONG SIDE OF STREET

It should be noted that 27 of these "finishing" accidents, including 5 fatal accidents, involved pedestrians crossing in marked crosswalks. Therefore it would appear desirable, whenever marked crosswalks are installed, that special consideration be given to nighttime visibility and illumination.

CONCLUSIONS

The results of this study show that pedestrian accident ratios and crosswalk use ratios tend to cover a range of values depending on the type of intersection where the crosswalk is located. But, in general, more pedestrian accidents occur in marked crosswalks than in unmarked crosswalks by a ratio of approximately 6 to 1. Further comparison of the volume of pedestrians using the marked and unmarked crosswalks shows that the crosswalk use ratio is approximately 3 to 1. This would indicate, in terms of use, that approximately twice as many pedestrian accidents occur in marked crosswalks as in unmarked crosswalks.

Evidence suggests that this poor accident record is not due to the crosswalk being marked as much as it is a reflection on the pedestrians' attitude and behavior when using the marked crosswalk.

In general, marked crosswalks have the following advantages.

1. They may help pedestrians orient themselves and find their way across complex intersections.
2. They may help show pedestrians the shortest route across traffic.
3. They may help show pedestrians the route with the least exposure to vehicular traffic and traffic conflicts.
4. They may help position pedestrians where they can be seen best by oncoming traffic.
5. They may help utilize the presence of luminaires to improve pedestrian nighttime safety.
6. They may help channelize and limit pedestrian traffic to specific locations.
7. They may aid in enforcing pedestrian crossing regulations.
8. They may act, in a limited manner, as a warning device and reminder to motorists that this is a location where pedestrian conflicts can be expected.

Marked crosswalks also exhibit some disadvantages.

1. They may cause pedestrians to have a false sense of security and to place themselves in a hazardous position with respect to vehicular traffic.
2. They may cause the pedestrian to think that the motorist can and will stop in all cases, even when it is impossible to do so.
3. They may cause a greater number of rear-end and associated collisions due to pedestrians not waiting for gaps in traffic.
4. They may cause an increase in fatal and serious-injury accidents.
5. They may cause an increase in community-wide accident insurance rates.
6. They may cause a disrespect for all pedestrian regulations and traffic controls.

Unjustified and poorly located marked crosswalks may cause an increased expense to the taxpayers for installation and maintenance costs that may not be justified in terms of improved public safety. Indeed, such crosswalks may tend to increase the hazard to pedestrians and motorists alike. Therefore, the following recommendations are presented for further consideration and implementation.

RECOMMENDATIONS

1. Existing crosswalk warrants should be reviewed and updated. Special consideration should be given to pedestrian channelization needs, nighttime illumination, vehicle approach speed, and motorist inability to see pedestrians or the crosswalk at the critical safe stopping distance.
2. No new crosswalks should be installed unless they meet the conditions established by the warrants.
3. Existing crosswalks should be reevaluated to see whether they meet the revised warrants.

4. Efforts should be made to reeducate pedestrians regarding the limitations of the marked crosswalks and to alert them to some of the special hazards that they may encounter while crossing streets.
5. Attention should be given to the long-range needs of the pedestrian when planning new communities and developing existing communities in order to reduce the conflict between pedestrian and vehicle.
6. Research should be continued on a national scale to gain a better understanding of the pedestrian safety problem and to seek workable solutions and alternatives to the problem.

In conclusion, it is appropriate to restate that marked crosswalks will continue to be a useful traffic control device. But it is important that the general public recognize what marked crosswalks can and cannot do. It is also important that public officials not install them unless the anticipated benefits clearly outweigh the risks discussed in this report.

ACKNOWLEDGMENTS

This project was conducted by the City of San Diego as part of the California Traffic Safety Program and was made possible through the support of the Office of Traffic Safety, State of California, and the National Highway Safety Bureau. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of California or the National Highway Safety Bureau. Appreciation is directed to Professor Wolfgang Homburger and Mr. Ray Ward for their guidance. Special acknowledgment is given to Mr. David Crawford and Mr. Pierre Paddock for their valuable assistance, Mr. Phillip Binks for the accompanying photographs, Miss Darlene McAfee for typing the text, and the many others who assisted in this project.

REFERENCES

1. AAA Foundation for Traffic Safety. Planned Pedestrian Program. Washington, D. C., 1958.
2. Automotive Safety Foundation. Traffic Control and Roadway Elements. Washington, D. C., 1963.
3. Bureau of Public Roads. Manual on Uniform Traffic Control Devices for Streets and Highways. Washington, D. C., 1961.
4. California State Vehicle Code—1969. Sacramento, 1969.
5. City of San Diego. Policy—Pedestrian Crosswalks. Traffic Engineering Section, revised Jan. 1967.
6. Cleveland, Donald E. (editor). Manual of Traffic Engineering Studies, Third Edition. ITE, Washington, D. C., 1964.
7. Crawford, David W., and Herms, Bruce F. Pedestrian Crosswalk Study (Preliminary). City of San Diego, Traffic Engineering Div., June 1968.
8. Glanville, William H. Safety on the Road. Jour. Royal Society of Arts, May 1954.
9. Haddon, W., Suchman, E. A., and Klein, D. Accident Research—Approaches and Methods. Harper and Row, 1964.
10. Herms, Bruce F. Some Visual Aspects of Pedestrian Crosswalks. Proc. 22nd California Street and Highway Conf., ITTE, Univ. of California, Jan. 1970.
11. Institute of Traffic Engineers. Traffic Engineering Handbook, Third Edition. 1965.
12. Kennedy, N., Kell, J., and Homburger, W. Fundamentals of Traffic Engineering, 7th Edition. Univ. of California, Berkeley, 1969.
13. Matson, T. M., Smith, W. S., and Hurd, F. W. Traffic Engineering. McGraw-Hill Book Co., New York, 1955.
14. Moore, R. L. Pedestrian Choice and Judgment. Operational Research Quarterly, Vol. 4, No. 1, March 1953.
15. National Safety Council. Accident Facts—1969 Edition. Chicago, 1969.

1972
HIGHWAY RESEARCH BOARD

OFFICERS

Alan M. Voorhees, *Chairman*
William L. Garrison, *First Vice Chairman*
Jay W. Brown, *Second Vice Chairman*
W. N. Carey, Jr., *Executive Director*

EXECUTIVE COMMITTEE

A. E. Johnson, *Executive Director, American Association of State Highway Officials* (ex officio)
Ralph R. Bartelsmeyer, *Acting Federal Highway Administrator, U.S. Department of Transportation* (ex officio)
Carlos C. Villarreal, *Urban Mass Transportation Administrator, U.S. Department of Transportation* (ex officio)
Ernst Weber, *Chairman, Division of Engineering, National Research Council* (ex officio)
D. Grant Mickle, *President, Highway Users Federation for Safety and Mobility* (ex officio, Past Chairman 1970)
Charles E. Shumate, *Executive Director, Colorado Department of Highways* (ex officio, Past Chairman 1971)
Hendrik W. Bode, *Gordon McKay Professor of Systems Engineering, Harvard University*
Jay W. Brown, *Director of Road Operations, Florida Department of Transportation*
W. J. Burmeister, *Executive Director, Wisconsin Asphalt Pavement Association*
Howard A. Coleman, *Consultant, Missouri Portland Cement Company*
Douglas B. Fugate, *Commissioner, Virginia Department of Highways*
William L. Garrison, *Edward R. Weidlein Professor of Environmental Engineering, University of Pittsburgh*
Roger H. Gilman, *Director of Planning and Development, Port of New York Authority*
George E. Holbrook, *E. I. du Pont de Nemours and Company*
George Krambles, *Superintendent of Research and Planning, Chicago Transit Authority*
A. Scheffer Lang, *Office of the President, Association of American Railroads*
John A. Legarra, *Deputy State Highway Engineer, California Division of Highways*
William A. McConnell, *Director, Product Test Operations Office, Product Development Group, Ford Motor Company*
John J. McKetta, *Department of Chemical Engineering, University of Texas*
John T. Middleton, *Deputy Assistant Administrator, Office of Air Programs, Environmental Protection Agency*
Elliott W. Montroll, *Albert Einstein Professor of Physics, University of Rochester*
R. L. Peyton, *Assistant State Highway Director, State Highway Commission of Kansas*
Milton Pikarsky, *Commissioner of Public Works, Chicago*
David H. Stevens, *Chairman, Maine State Highway Commission*
Alan M. Voorhees, *President, Alan M. Voorhees and Associates, Inc.*
Robert N. Young, *Executive Director, Regional Planning Council, Baltimore*

HIGHWAY RESEARCH RECORD

Number 406

Pedestrian Protection

5 reports
prepared for the
51st Annual Meeting

Subject Areas

51 Highway Safety
52 Road User Characteristics

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING
1972
Washington, D.C.